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Takasaki

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(54) **BATTERY MODULE**

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H01M 2/10 (2006.01)

(52) **U.S. Cl.**
CPC ***H01M 2/1077*** (2013.01); ***H01M 2/105*** (2013.01); *H01M 2220/20* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

A battery module includes a plurality of battery blocks formed by arranging a plurality of unit cells in each block; and a hollow spacer placed between two adjacent battery blocks. The accommodation member and the spacer may be made of the same metal material. The spacer may be formed to include an insulation member for insulating two joined battery blocks from each other.

4 Claims, 5 Drawing Sheets

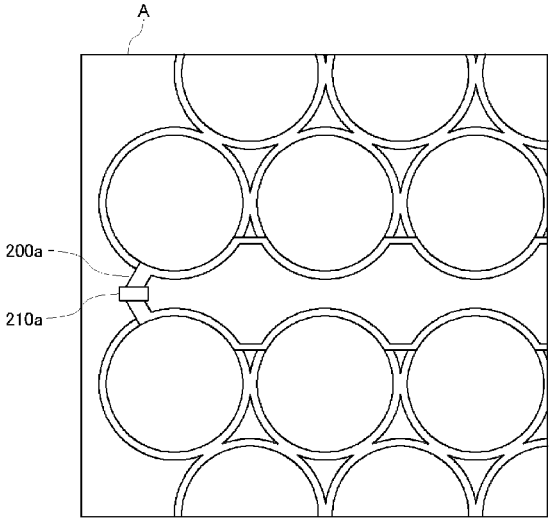
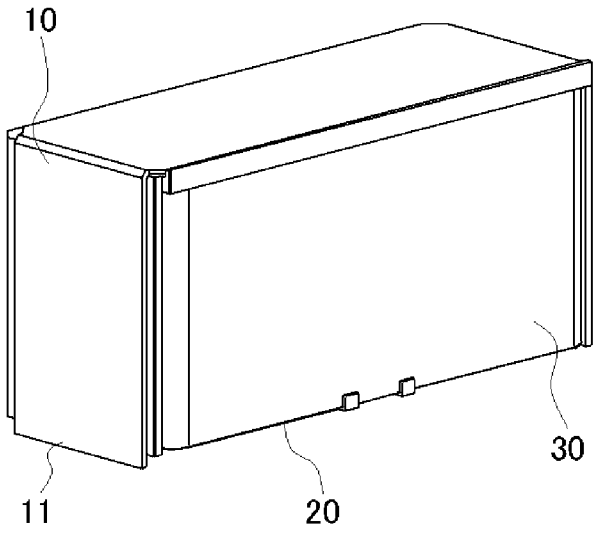
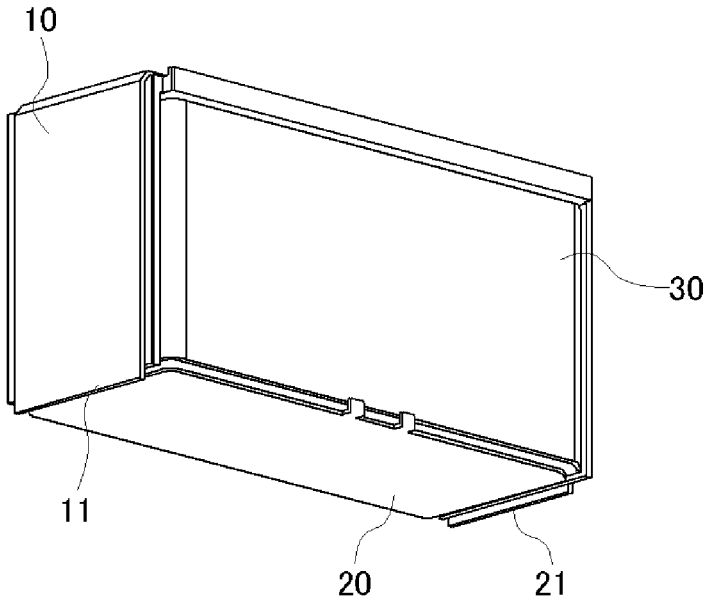


FIG.1A



100

FIG.1B



100

FIG.2

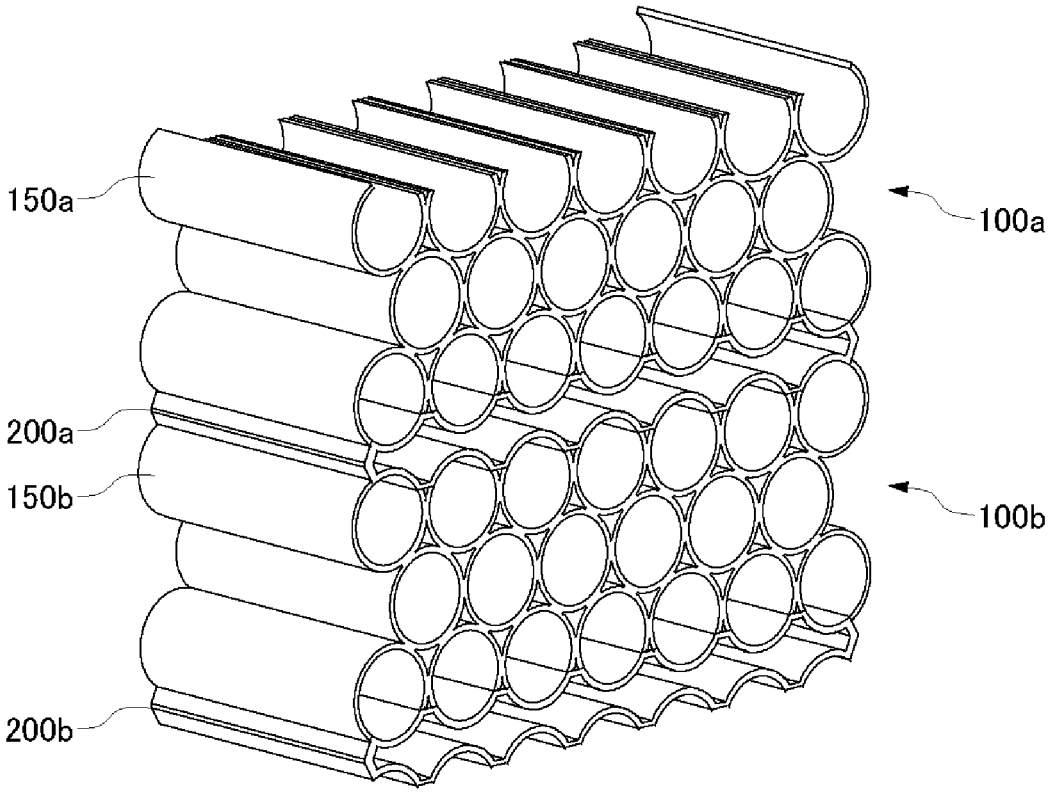


FIG.3

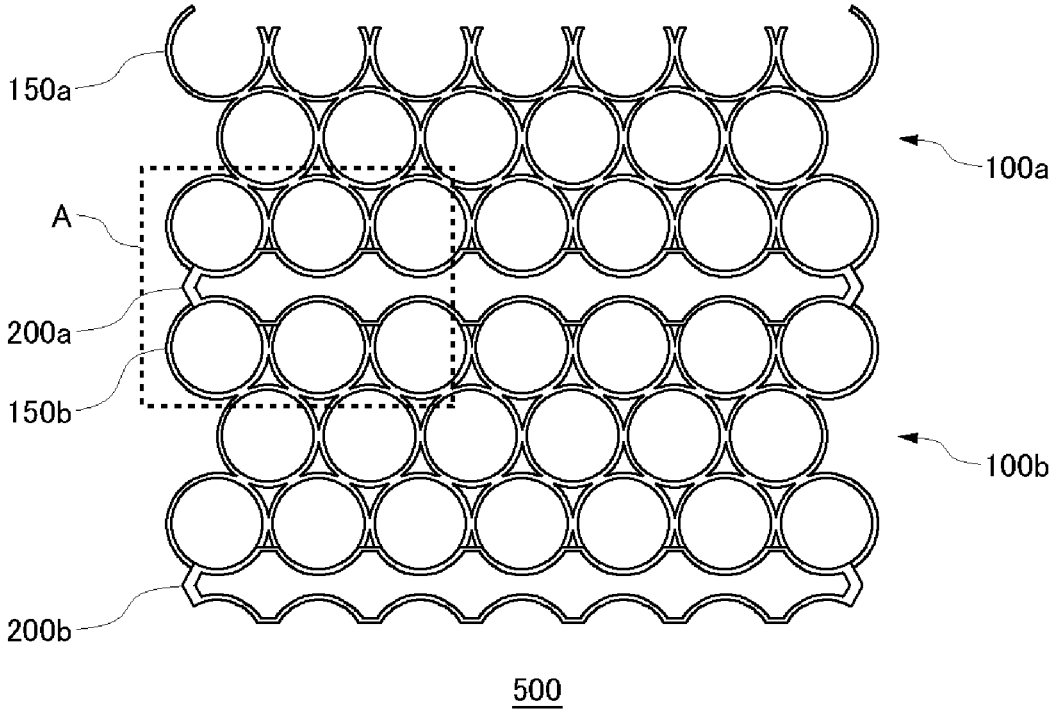


FIG.4

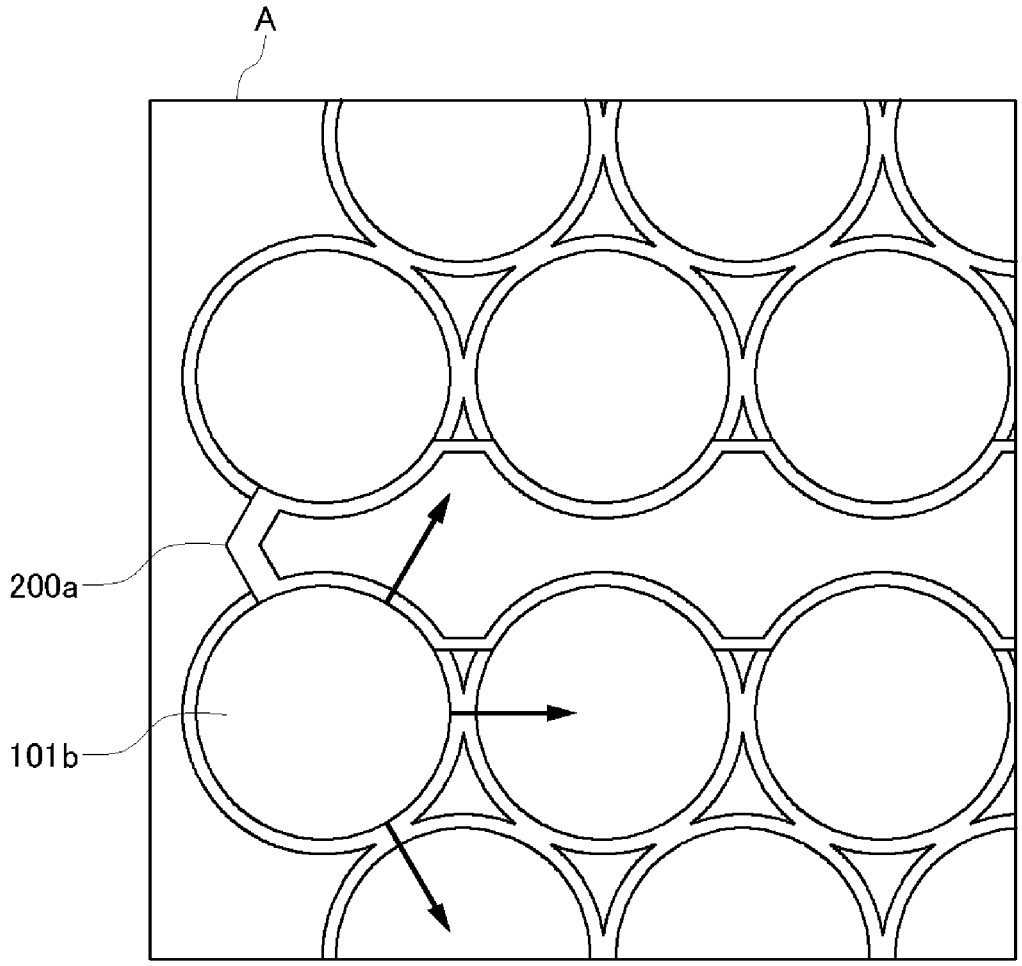
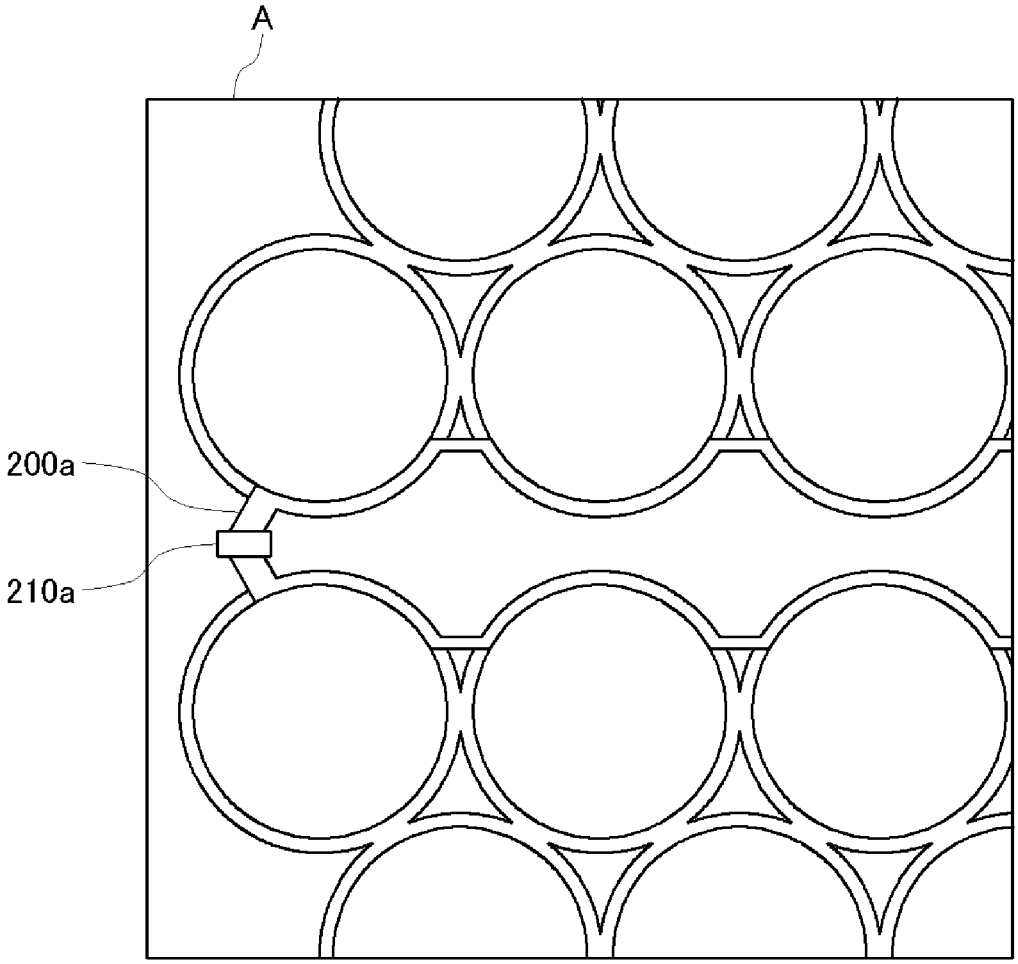


FIG.5



BATTERY MODULE

RELATED APPLICATIONS

This application is a national phase of International Application No. PCT/JP2012/006189, filed on Sep. 27, 2012, the disclosure of which Application is incorporated by reference herein.

TECHNICAL FIELD

The present invention relates to a battery module provided with a plurality of battery blocks.

BACKGROUND ART

Recently, hybrid vehicles (HV), plog-in HVs (PHV), and electric vehicles (EV) have become popular. A key device mounted in these eco-friendly cars is a secondary battery. Nickel hydride batteries and lithium-ion batteries are most popular on-vehicle secondary batteries. It is expected that the popularity of lithium-ion batteries will be accelerated in the future because of high energy density and absence of memory effect.

Because on-vehicle secondary batteries can achieve high output and high capacity, a large number of unit cells are connected for use. Normally, on-vehicle secondary batteries are provided as battery packs in which a plurality of battery blocks are connected. A plurality of unit cells are arranged in each battery block. On-vehicle secondary batteries provide high output and clear high safety criteria so that a thermal process carries weight. In principle, secondary batteries in which lithium-ion batteries are used produce larger heat than other batteries.

[patent document 1] JP2007-141511

[patent document 2] JP2011-171175

Problem To Be Solved By The Invention

The present invention addresses this requirement and a purpose thereof is to provide a technology of achieving secondary battery packaging with high pyrogenic tolerance.

Means To Solve The Problem

To address the aforementioned issue, the battery module according to an embodiment of the present invention includes a plurality of battery blocks formed by arranging a plurality of unit cells in each block; and a hollow spacer placed between two adjacent battery blocks.

Advantage Of The Present Invention

The present invention realizes a secondary battery packaging with high pyrogenic tolerance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A-**1**B are perspective views showing the configuration of a battery block according to a comparative example;

FIG. **2** is a perspective view showing the configuration of a battery module according to an embodiment of the present invention;

FIG. **3** a plan view showing the configuration of the battery module according to the embodiment of the present invention;

FIG. **4** is an enlarged view of region A of FIG. **3**; and

FIG. **5** shows a battery module according to a variation.

Best Mode For Carrying Out The Invention

FIGS. **1**A-**1**B are perspective views showing the configuration of a battery block **100** according to a comparative example. FIG. **1**A is a perspective view from above and FIG. **1**B is a perspective view from below. The battery block **100** is configured by arranging a plurality of unit cells (not shown) such that the positive electrodes face the same direction. A unit cell is a cylindrical secondary battery and a power generation unit is accommodated in a battery case. Each unit cell has a positive electrode and a negative electrode. FIGS. **1**A-**1**B depict the positive electrodes of the unit cells facing upward.

A block case **30** is provided to cover the four outer lateral surfaces of the plurality of unit cells arranged in a hexagonal lattice. A positive electrode plate **10** covers the top surface on which the positive electrode ends of the plurality of unit cells are located. The positive electrode plate **10** is a member for electrically connecting the positive electrodes of the plurality of unit cells. Similarly, a negative electrode plate **20** covers the bottom surface on which the negative electrodes ends of the plurality of unit cells are located. The negative electrode plate **20** is a member for electrically connecting the negative electrodes of the plurality of unit cells. This establishes electrical parallel connection of the plurality of unit cells.

The positive electrode plate **10** is formed in an L-shape and is mounted on the part of the block case **30** covering the short-width lateral surface so as to extend over one of the two lateral surfaces (hereinafter, referred to as short-width lateral surface) of the four outer lateral surfaces with relatively smaller areas. The end of the positive electrode plate **10** covering the short-width lateral surface extends beyond the short-width lateral surface. The negative electrode plate **20** has a flange **21** opposite to an extension **11** of the positive electrode plate **10** so as to face the extension **11** of the positive electrode plate **10**.

When a plurality of battery blocks as shown in FIGS. **1**A-**1**B are connected to form a battery module, the battery blocks are joined such that the short-width lateral surfaces of the two adjacent battery blocks are in contact with each other. The extension **11** of the positive electrode plate **10** and the flange **21** of the negative electrode plate **20** are welded so that the two battery blocks are electrically connected in series. Three or more battery blocks can be joined using a similar joining method. The plurality of battery blocks connected in series as described above and another set of a plurality of battery blocks connected in series can be arranged such that their long-width lateral surfaces thereof are in contact with each other so as to form a two-dimensional array of battery blocks. In this process, series-parallel electrical connection can be established by connecting the electrodes at the ends of the two battery blocks in series connection, using a bus bar. Generally, the two-dimensional array of battery blocks described above are accommodated in a case so as to form a battery module.

FIG. **2** is a perspective view showing the configuration of a battery module **500** according to an embodiment of the present invention. FIG. **3** a plan view showing the configuration of the battery module **500** according to the embodiment of the present invention. The battery module **500** according to the embodiment is configured such that a plurality of battery blocks **100** are joined using spacers **200**. Referring to FIGS. **2** and **3**, a first battery block **100***a* and a

second battery block **100***b* are joined by a first spacer **200***a*. The figures show a second spacer **200***b* joined to the surface of the second battery block **100***b* opposite to the surface of joint with the first battery block **100***a*. If the number of battery blocks **100** forming the battery module **500** is 2, the second spacer **200***b* may be omitted.

Each battery block **100** is provided with an accommodation member **150**. The plurality of cylindrical parts of the accommodation member **150** that respectively accommodate a plurality of columnar unit cells form a hexagonal lattice. Referring to FIGS. **2** and **3**, the first battery block **100***a* has a first accommodation member **150***a* in which 20 cylindrical parts that accommodate 20 unit cells, respectively, form a hexagonal lattice. Like the first battery block **100***a*, the second battery block **100***b* also has a second accommodation member **150***b*. Constituting elements of the battery blocks **100** shown in FIGS. **2** and **3** other than the accommodation members **150** are omitted from the illustration. In other words, the unit cells, positive electrode plates, negative electrode plates, and other case members are omitted from the illustration.

On the lateral surfaces of the accommodation member **150** that should be joined to the spacer **200**, a portion of the circumference of the cylindrical part is opened. Referring to FIGS. **2** and **3**, a portion of the circumference of the cylindrical parts in the two outer rows of the three rows is opened. More specifically, the outer arc on the circumference is opened (at an angle of about 120°). The accommodation member **150** is made of metal. For example, the accommodation member **150** is made of aluminum or an alloy composed mainly of aluminum.

The spacer **200** is placed between adjacent battery blocks. The lateral surface of the spacer **200** is wave-shaped so as to define a portion of the circumference of the accommodation member **150** that is opened. The spacer **200** is a hollow member. A hollow is formed in a direction parallel to the direction of accommodating the unit cells in the accommodation member **150**. The lateral surface of the spacer **200** in contact with the accommodation member **150** is formed with a recess of a shape corresponding to the opened outer arc of the cylindrical part of the accommodation member **150**. In the example shown in FIGS. **2** and **3**, seven recesses are formed in each lateral surface. The ends of the outer opened arc of each cylindrical part of the accommodation member **150** is welded to the ends of the associated recess formed on the lateral surface of the spacer **200** with the result that the cylindrical part is turned into a completely closed cylindrical part.

Preferably, the spacer **200** is made of the same material as the accommodation member **150**. According to the embodiment, the accommodation member **150** and the spacer **200** are made of the same metal material (e.g., aluminum). The thickness of each cylindrical part of the accommodation member **150** is configured to be substantially identical to the thickness of the joint surface of the spacer **200** joined to the accommodation member **150**. Preferably, the thickness of the two lateral surfaces of the spacer **200** joining the joint surfaces is designed to be thicker than the thickness of the joint surfaces.

Referring to FIGS. **2** and **3**, the second spacer **200***b* is joined to the surface of the second battery block **100***b* opposite to the surface of joint to the first battery block **100***a*. By joining another battery block to the opposite joint surface of the second spacer **200***b*, an additional battery block can be joined. By joining the battery modules **500** shown in FIGS. **2** and **3**, a new battery module **500** provided with four battery blocks can be produced.

The battery block **100** at the ends of the battery module **500** may be of a type in which the outer cylindrical part not joined to an adjacent block is not opened. Alternatively, a lid member (not shown) may be joined to cover the opened portion of the circumference.

The shape and position of installation of the positive electrode plate and the negative electrode plate provided in each battery block **100** constituting the battery module **500** are non-limiting in this embodiment. The requirement is that a parallel circuit may be formed by the 20 unit cells included in each battery block **100**.

The battery blocks **100** constituting the battery module **500** may be arranged such that the polarities alternate. Given that the positive electrode of the unit cell of the first battery block **100***a* faces upward, the adjacent second battery block **100***b* may be arranged such that the negative electrode faces upward. In this case, the positive electrode plate of the first battery block **100***a* can be located on the same plane as the negative electrode plate of the second battery block **100***b*, and the negative electrode plate of the first battery block **100***a* can be located on the same plane as the positive electrode plate of the second battery bock **100***b*. Thus, by connecting the positive electrode plate with the negative electrode plate and connecting the negative electrode plate with the positive electrode plate, a series circuit comprising the first battery block **100***a* and the second battery block **100***b* can be easily formed.

FIG. **4** is an enlarged view of region A of FIG. **3**. If a first unit cell **101***b* of the second battery block **100***b* generates abnormal heat, the heat is propagated to the first battery block **100***a* via the first spacer **200***a* as well as to the second battery block **100***b*. By propagating the heat over an extensive range, heat dissipation of the unit cell generating abnormal heat is promoted. By using the same material for the spacer **200** and the accommodation member **150** of each battery block **100**, the spacer **200** and the accommodation member **150** will exhibit the same thermal conductivity so that heat can be propagated uniformly.

Since the spacer **200** is hollow, the cooling air flows through the spacer **200**, thereby efficiently cooling the unit cell generating abnormal heat. Because the cooling air flows between the battery blocks **100** during normal operation as well, the temperature of the battery blocks **100** is prevented from increasing. In applications where severe temperature management of the battery module **500** is required (e.g., on-vehicle applications), a fan for feeding cooling air to the spacer **200** may be installed in the neighborhood of the battery module **500**.

FIG. **5** shows the battery module **500** according to a variation. In this variation, the spacer **200** is formed to include an insulation member for insulating the two joined battery blocks **100** from each other. In the example shown in FIG. **5**, an insulation member **210** is sandwiched in each of the two lateral surfaces joining the joint surface of the first spacer **200***a* joined to the first battery block **100***a* and the joint surface of the first spacer **200***a* joined to the second battery block **100***b*, so as to insulate the joint surfaces from each other. The insulation member **210** may be made of a resin material. In this case, the spacer **200** may be formed by insert molding using a metal material and a resin material. The entirety of the spacer **200** may be made of a resin with high rigidity.

If the first battery block **100***a* and the second battery block **100***b* are electrically connected in series as described above, a potential difference is created between the first battery block **100***a* and the second battery block **100***b*. The first battery block **100***a* and the second battery block **100***b* may

be short-circuited for some reason and a large current may flow from one of the blocks to the other via the spacer **200**. By sandwiching an insulation member in the spacer **200** as in this variation, a large current is prevented from flowing between the battery blocks **100** via the spacer **200**.

As described above, the battery module **500** according to the embodiment provides packaging with high pyrogenic tolerance by joining the battery blocks **100** using the hollow spacer **200**. By configuring one lateral surface of the spacer **200** to form a part of the accommodation member **150** of the unit cell located at the joint surface, the unit cell can be cooled more directly. Since the joint surface is arc-shaped, the unit cell can be cooled with a larger area than by using a flat shape. By using the spacer **200**, which serves as a heat dissipation member and also as a joint member, packaging with high pyrogenic tolerance and high expandability is realized.

Described above is an explanation based on an exemplary embodiment. The embodiment is intended to be illustrative only and it will be obvious to those skilled in the art that various modifications to constituting elements and processes could be developed and that such modifications are also within the scope of the present invention.

The spacer **200** is described above as being made of aluminum but may be made of another metal material such as copper. The accommodation member **150** and the spacer **200** may be separately made of the same material or different materials. Alternatively, the accommodation member **150** and the spacer **200** may be made in one piece, using the same material.

The invention according to the embodiment may be defined by the following items.

[Item 1]

A battery module comprising:

a plurality of battery blocks formed by arranging a plurality of unit cells in each block; and

a hollow spacer placed between two adjacent battery blocks.

[Item 2]

The battery module according to item 1, wherein the battery block includes an accommodation member having a plurality of cylindrical parts that accommodate the plurality of unit cells respectively, and the accommodation member and the spacer are made of a metal material.

[Item 3]

The battery module according to item 1 or 2, wherein the spacer is formed to include an insulation member for insulating two joined battery blocks from each other.

[Item 4]

The battery module according to item 1 or 3, wherein the battery block includes an accommodation member in which a plurality of cylindrical parts that respectively accommodate a plurality of columnar unit cells are arranged in a hexagonal lattice, a portion of the circumference of the cylindrical part on lateral surfaces of the accommodation member that should be joined to the spacer is opened, and the lateral surface of the spacer is wave-shaped so as to define a portion of the circumference of the accommodation member that is opened.

DESCRIPTION OF THE REFERENCE NUMERALS

500 battery module, **100** battery block, **150** accommodation member, **200** spacer, **210** insulation member

INDUSTRIAL APPLICABILITY

The present invention is applicable to on-vehicle secondary batteries and electricity storage systems.

The invention claimed is:

1. A battery module comprising:

a plurality of battery blocks formed by arranging a plurality of unit cells in each block; and

a hollow spacer placed between two adjacent battery blocks, including an insulation member sandwiched between an upper portion of the hollow spacer adjacent to a one of the plurality of battery blocks and a lower portion of the hollow spacer adjacent to another of the plurality of battery blocks, such that the upper and lower portions of the hollow spacer are insulated from each other.

2. The battery module according to claim **1**, wherein

the battery block includes an accommodation member having a plurality of cylindrical parts that accommodate the plurality of unit cells respectively, and the accommodation member and the spacer are made of a metal material.

3. The battery module according to claim **1**, wherein

the spacer is formed to include an insulation member for insulating two joined battery blocks from each other.

4. The battery module according to claim **1**, wherein

the battery block includes an accommodation member in which a plurality of cylindrical parts that respectively accommodate a plurality of columnar unit cells are arranged in a hexagonal lattice, a portion of the circumference of the cylindrical part on lateral surfaces of the accommodation member that should be joined to the spacer is opened, and the lateral surface of the spacer is wave-shaped so as to define a portion of the circumference of the accommodation member that is opened.

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